Evaluating Grazing and Climate Effect on Rangelands Cover and Production

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Overview

As defined in Walbridge and Shafer (2012) and the Shared Research Strategy (Bryant et al., 2013]), the Long Term Agro-Ecosystem Research (LTAR) Network is designed to create a national network built around intensively studied research sites that characterize agriculture within the region surrounding each site. The four priority areas for the LTAR are:

1. Agro-ecosystem productivity (productivity);
2. Climate variability and change (climate);
3. Conservation and environmental quality (sustainability);
4. Socio-economic viability and opportunities (economics).

The purpose of this work is to demonstrate how freely available data from the Landsat and MODIS sensors can be used to extrapolate variables measured in the field at LTAR sites across the western rangelands to the areas that individual sites represent, and more generally, using all datasets across western rangelands. As always with remote sensing, we expect data for testing the extrapolation will be limited, but we hope to use secondary datasets as they become available.

Objectives

- ❑ To assess the ability of MODIS imagery to quantify annual vegetation cover, production, and value as forage on rangelands as a function of climate, management and inherent productive potential across the Boise-ID, Cheyenne-WY, El Reno-OK, Jornada-NM, Nunn-CO, Mandan-ND, Miles City-MT, and Walnut Gulch Experimental Watershed-AZ locations.

- ❑ To serve as a model for how other agricultural systems could link field sites with regional and national assessments.

Research Question & Hypotheses

The **research question** addressed here is essentially a subset of the overall LTAR project, namely, on western rangelands: *How do climate and management interact to produce vegetation communities that can be more productive, be sustainable, continue to function under potentially new expected climate regimes, and be economically viable?*

Hypotheses:

- ❑ Time integrated satellite-based greenness index used as primary productivity proxy correlates significantly with grazing-related activities (grasslands cover/productivity and cattle weight gain) of the U.S. western rangelands

- ❑ During those years with warmer and drier than average conditions, management practices maintain productivity at levels higher than expected given climate

Study Sites

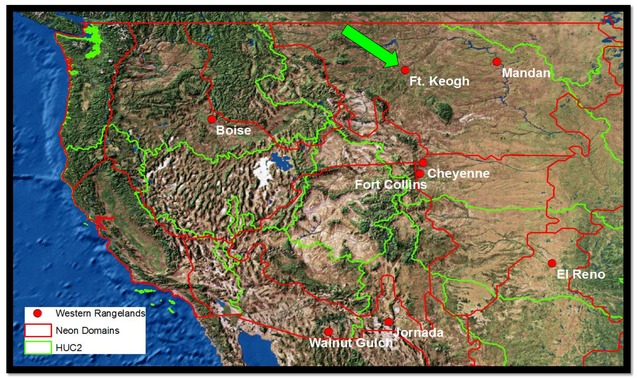

Figure 1. Location of the U.S. western rangelands. Ft. Keogh in Montana is the initial site for developing the methodologies to apply across the other rangelands.

Data & Methods

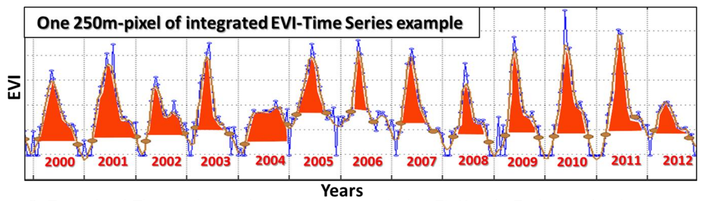

Figure 2. Example of *Timesat* time series output for one pixel at Ft. Keogh. Red area showing an example of small integration during growing season (iEVI). In this example the brown line is the smoothed time series and the blue line the original time series. Different integration methods are being tested.

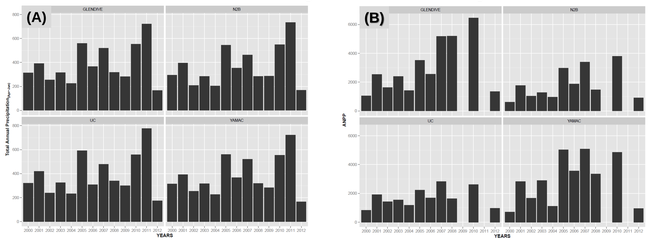

Figure 3. (A) Total summer precipitation (Apr-Jun) for each site (2000-2012) at Ft. Keogh using DAYMET dataset, (B) *In-situ* ANPP at each one of the locations. At each location, an exclosure area of 50 m2 with 20 plots (0.25 m2 each) were used for the annual clipping process.

References

- Bryant, R., K. Havstad, P. Heilman, P. Kleinman, T. Moorman, S.M. Moran, J.L. Steiner, and T. Strickland. 2012. Long Term Agro-Ecosystem Research Network: Shared Research Strategy. LTAR
- Jonsson, P., and L. Eklundh, TIMESAT- a program for analyzing time-series of satellite sensor data, Comp. & Geosci., 30 (8), 833{845, doi:10.1016/j.cageo.2004.05.006, 2004.
- Walbridge, M.R. and S.R. Shafer, 2012. Establishing a Long- Term Agro-ecosystem Research (LTAR) Network. In: Proc. 21st Century Watershed Technology Conference and Workshop Im-proving Water Quality and the Environment, Bari, Italy, May 27-June 1, 2012
- Huete, A. et al., Overview of the radiometric and biophysical performance of the MODIS vegetation indices, Remote Sens Environ, 83 (1-2), 195{213, doi:10.1016/S0034-4257(02)00096-2, 2002

Preliminary Results

Landsat-Peak of Season and MODIS iEVI at Fort Keogh

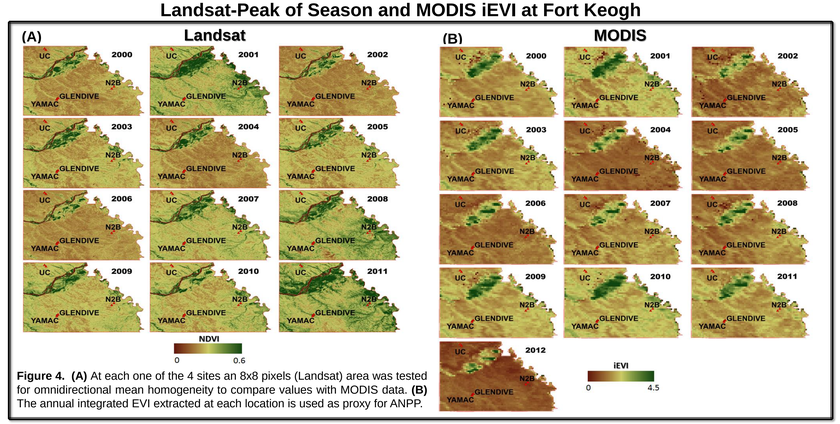

Figure 4. **(A)** At each one of the 4 sites an 8x8 pixels (Landsat) area was tested for omnidirectional mean homogeneity to compare values with MODIS data. **(B)** The annual integrated EVI extracted at each location is used as proxy for ANPP.

ANPP - iEVI - Precipitation 2000-2012 Relationships at four sites in Ft. Keogh

Figure 5. (A-B) Show the correlation of satellite data (Landsat-NDVI and MODIS-iEVI respectively) with *in-situ* ANPP across the four sites in Ft. Keogh with red circles indicating those years with a significant variability in ANPP. **(C)** The relationship of total annual precipitation$_{(Apr\text{-}Jul)}$ (TAP) and *in-situ* ANPP and **(D)** showing the relationship of TAP with iEVI. **(E)** A comparison of the coefficient of variation between the *in-situ* ANPP and iEVI with a mean CV of 56% for ANPP and 29% for iEVI values. **(F)** The correlation of normalized values of ANPP and iEVI across the non-grazed (R=0.6) and grazed (R=0.5) with a non-significant difference in the relationship between the two management practices.

Future Work

- ❑ Starting using data sets from other rangelands involved in this project

- ❑ Model assessment to explain iEVI variability and improve *in-situ ANPP- iEVI correlation*

- ❑ Evaluate the impact of climate change on rangelands productivity incorporating climate data sets from PRISM and AHPS

- ❑ Analyze the sustainability, productivity and economics of U.S. western rangelands under altered hydroclimatic conditions (AHC) using a partial budgeting approach

Forage Cost = Input Prices × Quantity } ***Main factors impacted by AHC***